Remarks

Further and favorable reconsideration is respectfully requested in view of the foregoing amendments and following remarks.

Initially, Applicant submits herewith a substitute specification, in proper idiomatic English, as requested by the Examiner. The substitute specification contains no new matter.

Claim 1 has been amended to recite that a difference of non-volatile contents between a non-volatile content of aqueous paint during spray coating and a non-volatile coating of wet coating after one minute setting is controlled to a suitable range. This is supported by the disclosure in paragraph [0010] on pages 3-4 of the specification.

Claim 4 has been added to the application, and is also supported by paragraph [0010], more specifically, at page 4, line 5.

The patentability of the present invention over the disclosure of the reference relied upon by the Examiner in rejecting the claims will be apparent upon consideration of the following remarks.

Thus, the rejection of claims 1-3 under 35 U.S.C. § 102(b) as being anticipated by Govindan is respectfully traversed.

The Examiner takes the position that Govindan discloses a method for spray coating aqueous paint, characterized in that a portion of a spray gun is cooled or heated to adjust a temperature of aqueous paint passing through the spray gun. The Examiner further asserts that Govindan provides a shroud that surrounds the outside nozzle of the spray gun, and that air passing through the shroud is heated, thus heating the nozzle portion and the aqueous paint passing through the nozzle.

Applicant respectfully disagrees that the teachings of Govindan anticipate Applicant's pending claims.

The Govindan reference discloses an improved process which applies an aqueous paint to a substrate by air spraying a paint with a spray gun, wherein the improvement is utilizing an air shroud that substantially encircles the atomized paint spray with a cone or fan or air that is at about 15 to 95°C and has a flow rate of 10 to 250 cubic feet per minute (see the Abstract of the Govindan reference). The temperature of the air gun head of the

reference is therefore controlled to within the range of 15 to 95°C. However, the reference neither teaches nor suggests that the temperature is controlled to a suitable range within allowable volume absolute humidity, as presently claimed. The reference also does not suggest that the non-volatile content difference (Δ NV = $NV_2 - NV_1$) is controlled to a suitable range, as is now required by amended claim 1.

The Govindan reference merely suggests a suitable temperature range, air flow range and humidity range, but does not teach that these ranges have any relation to each other. On the contrary, in the present invention, the inventor has discovered that the relation of humidity and temperature is controlled based on allowable volume absolute humidity. This concept makes it easy to control the temperature and humidity, so that appearance of a coated film becomes good without sagging or defects of a coated surface. Allowable volume absolute humidity reduces the number of parameters from two (temperature and humidity) to one (page 4, lines 14-16 of the specification). This concept is not taught or suggested by the Govindan reference.

For these reasons, Applicant takes the position that the invention of claims 1-4 is clearly patentable over Govindan.

Therefore, in view of the foregoing amendments and remarks, it is submitted that each of the grounds of objection and rejection set forth by the Examiner has been overcome, and that the application is in condition for allowance. Such allowance is solicited.

Respectfully submitted,

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METHOD FOR SPRAY-COATING AQUEOUS PAINT

FIELD OF THE INVENTION

[0001] The present invention relates to a method for spray-coating aqueous paint, whereby coating defects raised by a change ~~of~~ in surrounding conditions, such as temperature and humidity, are avoided.

DEFINITION OF TERMS USED HEREIN

[0002] ~~By the~~ The term "allowable volume absolute humidity," in a unit of g/m^3, ~~employed herein is meant~~ means a difference between saturated volume absolute humidity and absolute humidity at a given temperature. The saturated volume absolute humidity means a maximum amount of water contained in gaseous form in the air of a unit volume.

BACKGROUND OF THE INVENTION

[0003] Aqueous paint (water-borne paint) mainly contains water as a solvent. Therefore, aqueous paint ~~and therefore~~ is not hazardous to the human body in coating conditions, and can easily treat, ~~in comparison with~~ when compared to solvent based paint (solvent-borne paint). ~~The aqueous~~ Aqueous paint is advantageously recycled by collecting ~~with aqueous solvent~~ an over-spray paint that has not been coated, with an aqueous solvent, on an article to be coated, filtering and concentrating the collected paint, ~~followed by~~ and adjusting the paint formulation for recycle use. The ~~recycle~~ recycling of aqueous paint reduces paint waste and ~~attains saving resource~~ saves resources. ~~The~~ Therefore, aqueous paint ~~therefore~~ has been widely used for industrial coating ~~field~~, such as automotive ~~coating~~ and home electric apparatus coating.

[0004] ~~Coating aqueous paint in~~ In a coating line for automotive bodies,

coating aqueous paint is generally conducted by spray-coating; wherein the aqueous paint is sprayed onto an article, employing a spray gun, to form a thin and uniform ~~coated~~ film coating on the article.

[0005] Aqueous paint, when spray-coated, is deposited onto an article, ~~as evaporating~~ allowing evaporation of some of the ~~solvent, i.e. water in the air,~~ solvent (i.e. water in the air), to result in forming a wet coating. The wet coating is then dried or baked to form ~~dried~~ a dry coating on the article.

[0006] Appearance of the ~~dried~~ dry coating significantly depends on both ~~an~~ the amount of water ~~evaporating from~~ evaporated from the aqueous paint during spray-coating and setting, ~~that is a~~ which is the time between spray-coating and drying or baking], and the flowability (i.e. viscosity) of the wet coating. The ~~evaporating~~ amount of water evaporated generally depends on the coating ~~surroundings of aqueous paint, that is~~ conditions, such as temperature and humidity. For example, when the coating temperature is too low and the humidity is too high, evaporation of water from the aqueous paint is so slow that the viscosity of the wet coating deposited on the article is lowered, and flowability is elevated, resulting in ~~generate so-called~~ "sagging" of the coated film. In addition, when the coating temperature is too high and the humidity is too low, evaporation of water from the aqueous paint is so accelerated that the wet coating becomes very ~~high viscosity and~~ viscous, with poor flowability, resulting in ~~generating so-called~~ "surface ~~blemish~~ blemishes" of the coated film.

[0007] It is also known ~~to~~ in the art that the viscosity of a wet coating increases as the non-volatile content of aqueous paint increases, ~~and~~

that the non-volatile content of wet coating changes the degree of water evaporation from aqueous paint ~~when~~ during coating. In order to prevent ~~from~~ surface defects, such as sagging or surface ~~blemish~~ blemishes, the viscosity of a wet coating should be controlled, not only by ~~adjustment of an~~ adjusting the amount of water ~~evaporation~~ evaporated from the aqueous paint indirectly, but also by ~~adjustment of~~ adjusting the non-volatile content of the aqueous paint directly, in accordance with ~~change of~~ changing coating conditions, such as temperature and humidity.

[0008] Coating conditions of aqueous paint in the prior art are generally controlled ~~at present~~ to a surrounding temperature of 15 to 35 °C, and a relative humidity of 60 to 90 %. However, it is ~~It is, however,~~ considered very difficult and ~~cost consuming that~~ expensive to optimize the non-volatile content of aqueous paint ~~is optimized timely in accordance~~ with a change of coating conditions, because coating conditions ~~are~~ actually ~~changed with time~~ change based upon the time of day (morning, day time or evening) ~~or season~~ and with the seasons. Even if the non-volatile content of aqueous paint is optimized, ~~the optimized aqueous paint~~ it should be utilized in ~~such~~ coating conditions where ~~evaporating~~ the amount of water evaporated is constant. This may be performed only in facilities ~~for making~~ where temperature and humidity are kept constant and ~~for covering with such~~ where a hood ~~over~~ is used to cover both ~~a~~ the portion introducing the aqueous paint into a spray gun and ~~a~~ the portion coating the paint on articles. ~~Such~~ These facilities seem cost consuming.

OBJECT OF THE INVENTION

[0009] The present invention is to provide a method for spray-coating aqueous paint wherein the non-volatile content of aqueous paint is adjusted in accordance with a change of coating conditions (temperature and humidity), and ~~evaporating~~ wherein the amount of water evaporated from the aqueous paint is controlled, without complicated and ~~cost-consuming~~ expensive operations, ~~to result in forming;~~ resulting in the formation of coatings having a good appearance, without surface defects, such as sagging and surface ~~blemish~~ blemishes.

SUMMARY OF THE INVENTION

[0010] As the result of studying ~~a~~ the relation between paint viscosity and the non-volatile content (NV) in paint, the present inventors have found that excellent appearance ~~would~~ can be obtained by controlling ~~a~~ the temperature of the aqueous paint (paint temperature) during spray coating, such as ~~a~~ the difference (Δ NV = NV_2 - NV_1) between NV (NV_1) of aqueous paint during spray coating and NV (NV_2) of wet coating after one minute. The inventors have controlled this value to be ~~setting is~~ within the preferred range of 3 to 8 %.

[0011] The NV_2 for wet coating also changes ~~in accordance with change of~~ depending on the surrounding temperature and humidity. For example, NV_2 ~~becomes higher at a condition of~~ increases with high temperature and low humidity, ~~in comparison with a condition of~~ compared to low temperature and high humidity, because the wet coating ~~is dried~~ dries much more with the former conditions. ~~The~~ This change ~~of~~ in NV_2 in turn changes Δ NV. In view of the above, the present inventors have now introduced the concept of allowable volume

absolute humidity, which ~~that~~ is calculated from surrounding temperature and humidity, in order to adjust paint temperature, whereby Δ NV is adjusted to within the preferred ~~ranges~~ range (3 to 8 %). The ~~introduction~~ concept of allowable volume absolute humidity reduces the number of parameters from two, ~~i.e.~~ (temperature and humidity), to one.

[0012] Accordingly, the present invention provides a method for spray-coating aqueous paint, ~~characterized in that~~ wherein a portion of a spray gun, especially a gun tip, is cooled or heated to adjust ~~a~~ the temperature of aqueous paint passing through the spray gun to a suitable range ~~within allowable volume absolute humidity during spray coating, so that~~. This range is within the allowable volume absolute humidity, permitting the temperature of aqueous paint ~~maintains in~~ to remain in the optimum range, even with changes in both ~~in accordance with change of both~~ surrounding ~~temperatures~~ temperature and ~~surrounding humidities~~ humidity during spray coating.

[0013] In addition, the present invention provides that the temperature of paint is controlled to remain within a range ~~satisfying~~ according to the following equations:

$$aX^2 + bX + c \leq Y \leq dX^2 + eX + f$$

$$10 \leq X \leq 80$$

$$1 \leq Y \leq 15$$

wherein X ~~shows a~~ is the temperature of aqueous paint, Y ~~shows an~~ is the allowable volume absolute humidity, and a, b, c, d, e and f are coefficients that are specific to the aqueous paint employed and experimentally obtained.

BRIEF EXPLANATION OF DRAWINGS

[0014] Fig. 1 is a graph that shows a preferable temperature range of aqueous paint ~~temperature range against~~ and the allowable volume absolute humidity (g/m^3) ~~obtained from temperature and humidity in coating conditions~~.

DETAILED DESCRIPTION OF THE INVENTION

[0015] The present invention is characterized in that ~~a~~ the temperature of aqueous paint (aqueous paint temperature) is adjusted at spray coating. The term "at spray coating" ~~means not only~~ includes the time just before actually spray-coating the aqueous paint, and the time ~~but includes~~ before introducing the aqueous paint into the spray gun ~~for spray coating~~. The term "paint temperature" means ~~a~~ the temperature of the aqueous paint ~~at a time of erupting~~ when it erupts from ~~a~~ the spray gun tip.

[0016] According to the method of the present invention, the temperature of aqueous paint is controlled to within an optimum range ~~in accordance with change of both~~ depending on changes in surrounding temperatures and ~~surrounding~~ humidities during spray coating. The surrounding temperatures (°C) and surrounding relative humidities (%) are firstly determined during spray-coating. The determination of temperature and humidity can be conducted by conventional methods and devices.

[0017] The surrounding temperature and saturated vapor pressure of the solvent (i.e. water) at the temperature can be calculated to obtain saturated volume absolute humidity (g/m^3) which is then distracted from absolute humidity at the temperature to obtain allowable volume absolute humidity Y (g/m^3).

[0018] According to the present invention, the allowable volume absolute humidity Y is adjusted to fall within ~~a~~ the preferred range by controlling ~~an~~ the aqueous paint temperature X. Particularly, the paint temperature X is controlled within a range satisfying the following equations:

$$aX^2 + bX + c \leq Y \leq dX^2 + eX + f$$

$$10 \leq X \leq 80$$

$$1 \leq Y \leq 15$$

wherein X ~~shows a~~ is the temperature of aqueous paint, Y ~~shows an~~ is the allowable volume absolute humidity, and a, b, c, d, e and f are coefficients that are specific to the aqueous paint employed and experimentally obtained. X is preferably within the range of 20 to 60 °C.

[0019] For example, when the aqueous paint is a dispersion-type aqueous paint, the a, b, c, d, e and f are ~~made~~ as follows: a = 0.0044, b = -0.4875, c = 15, d = 0.0053, e = -0.533 and f = 19.8. The inventors use the above equation, and these coefficients, to determine a preferred temperature X based on the allowable volume absolute humidity Y.

[0020] More concretely, the preferred aqueous paint temperature range is shown as oblique lines in Fig. 1 which shows a graph between allowable volume absolute humidity (g/m^3) and temperature of aqueous paint. Fig. 1 is for a dispersion-type aqueous paint.

[0021] According to the present invention, the paint temperature of aqueous paint is controlled and the ~~an evaporating~~ amount of water evaporated between spray coating and formation of wet coating ~~is always~~ remains within optimum range, even if the coating conditions, ~~such as~~ (temperature and humidity), change with time and season. As the result, coating defects, such as sagging and surface ~~blemish~~ blemishes, may be

significantly prevented and excellent surface appearance can be obtained.

[0022] Adjustment of paint temperature can be conducted by controlling a paint storage tank or a paint providing tank to constant temperatures, ~~but.~~ However, controlling the ~~temperature-control of whole of the~~ temperature of the entire tank is ~~structurally large and~~ expansive, complicated, and ~~cost-consuming~~ expensive. Since ~~whole of~~ all of the paint contained in the tank has to be temperature-controlled, the heat load applied to the paint becomes very large, and can even ~~changes~~ change paint quality. Accordingly, in the present invention, it is preferred to temperature-control a ~~potion of a~~ portion of the spray gun, especially ~~a~~ the spray gun tip. Temperature-control of a portion of ~~a~~ the spray gun, especially a spray gun tip, is very easy, and can be conducted by a smaller device, with lower energy loss. Temperature control ~~only at the~~ of only the spray gun tip is ~~not so~~ less complicated, and is conducted swiftly with time and condition.

[0023] In order to heat or cool at least a portion of the spray gun, especially the spray gun tip, any means known to the art can be employed. For example, a heating jacket or cooler with a conventional temperature controller (e.g. a thermostat) ~~is~~ may be equipped with the gun, ~~or a~~. Alternatively, water or air, having controlled temperature, ~~is~~ may be provided to the gun tip through a tube having high thermal conductivity.

EXAMPLES

[0024] The present invention is illustrated in details by the following Examples and Comparative Examples, which are not to be construed as

limiting the present invention to their details.

[0025] Examples 1 to 6 and Comparative Examples 1 to 3

In Examples and Comparative Examples, the following are used as aqueous paint, a coating machine and an article to be coated:

Aqueous paint : ADE RECYCLE F-2000 TMS Black (available from Nippon Paint Co., Ltd.

Spray coater : Wider 88 (available from Anest Iwata Co. Ltd.)

Article to be coated : 0.8 mm steel panel (SPCC -SD untreated panel)

[0026] In Examples 1 to 6, surrounding temperature and relative humidity before spray-coating were determined by temperature and humidity detectors each known to the art, from which each allowable volume absolute humidity Y was obtained. A paint temperature X was calculated from the equation using the allowable volume absolute humidity Y. In order to put the present invention to ~~practice use,~~ practical use, the aqueous paint provided to the portion of the spray gun ~~is~~ was temperature-controlled within the optimum temperature range in a short period of time before spray-coating in response to coating conditions which were changing with time. Therefore, information obtained from the temperature and humidity detectors ~~is~~ was input into a computer and calculated from the above mentioned equation to obtain optimum paint temperature. The ~~and a~~ temperature of the spray gun tip was adjusted by the computer system ~~from~~ based on the data input in the computer. Spray coating was conducted, using the temperature controlled spray gun onto the article to be coated and dried at 60 °C for 20 minutes. In ~~case~~ cases where the paint temperature of aqueous

paint was already ~~with~~ within the optimum paint temperature range, no further temperature control ~~had not be conducted and sprayed neatly~~ was required. Surface appearance of the coatings was visually evaluated and the results are shown in Table 1.

[0027] In Comparative Examples, the paint temperature X was set outside of the optimum range, although the surrounding temperature and humidity were determined. Spray coating and surface evaluation were conducted as generally described in Examples 1 to 6. The results are also shown in Table 1.

[0028] Table 1

Coating conditions	Examples						Comparative Examples		
	1	2	3	4	5	6	1	2	3
Surrounding temperature (°C)	25	25	25	25	25	25	25	25	25
Relative humidity (%)	70	57	88	70	90	70	88	57	57
Allowable volume absolute humidity Y (g/m^3)	7.0	9.8	2.8	7.0	2.6	7.0	2.8	9.8	9.8
Aqueous paint temperature X (°C)	20	20	40	40	60	60	25	40	60
Surface appearance	○	○	○	○	○	○	X^1	X^2	X^2

○ : No surface defects

X^1 : Sagging was observed.

X^2 : Surface blemish was observed.

[0029] As is apparent from the above Table 1, the coatings obtained in Examples 1 to 6, in which the aqueous paint temperature was adjusted within the range of optimum range, showed very good surface appearance. On the other hand, those of the Comparative Examples

showed poor surface appearance and indicated sagging or surface-blemish ~~blemish~~ blemishes.